Volume 5 issue 2 2025 (207-220)
Contents lists available at APSS
Journal of Advances in Para Sport Science (APSS)
Journal homepage: http://apssjournal.com/

Doi: 10.32604/mcb.2024.0xxxxx

ORIGINAL ARTICLE

A Prospective Epidemiological Study of Injuries in Para badminton athletes during a National Tournament

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Received: 16-08-2025; Accepted: 07-09-2025; Published: 06-10-2025

Abstract: Para badminton was one of the major sports which was included in Khelo India Paragames. Para badminton sport is physically challenging and it comprises of six classes. This study aimed to investigate the incidence and distribution of injury pattern in Para badminton players on the basis of gender, various categories of Para badminton athletes and combined wheelchair and non-wheelchair classes who participated in Khelo India Paragames 2025. A prospective epidemiological study was conducted that used the records from the medical help-desk. A total of 144 players were included in this study. Data on the athlete's identity, demographic characteristics and musculoskeletal injuries were extracted from the records of the medical help-desk. We calculated the incidence rate ratio and injury incidence rate, which is expressed as the number of injuries per 1000 hours of exposure. Women athletes demonstrate 27.20 injuries per 1000 athlete-hours compared to men's 8.00 injuries per 1000 athlete-hours. Wheelchair players experienced an injury incidence rate of 15.74 per 1,000 athlete-hours, while, non-wheelchair players recorded an injury incidence rate of 10.4 per 1,000 athlete-hours. Future research must rigorously investigate the optimal training volume required to prevent pain and injuries associated with Para sports players.

KEYWORDS: Para badminton, Epidemiology, Athlete, Injury.

Introduction

The Khelo India Para Games 2025 was the second edition of the multi-sport para event under the Indian government's Khelo India initiative. It was held in New Delhi across three venues, i.e. Indira Gandhi Stadium, Jawaharlal Nehru Stadium and Dr Karni Singh Shooting Range from March 20 to 27. The week-long Paralympics-style event brought together over 1,300 para-athletes from various states and Union

Territories. Medal events were held across six sports - **para archery, para athletics, para badminton, para shooting, para table tennis and para powerlifting.**

Para sport refers to any organized sporting event specifically designed for individuals with disabilities, distinguishing it from competitions intended for able-bodied participants (Gasibat et al., 2022), (Ersöz & Esen, 2023). It is important to acknowledge that injuries, an unfortunate and seemingly unavoidable aspect of sports participation, affect athletes with disabilities just as they do their able-bodied counterparts (Janiaczyk, 2015). Para badminton was one of the major sports which was included in Khelo India Paragames. Para badminton is a physically demanding sport that requires intricate and repetitive movements of both the upper and lower extremities, accompanied by continual variations in posture. This complexity results in a significant risk of overuse injuries affecting both appendicular and axial musculoskeletal systems (Webborn et al., 2006). Despite the increasing awareness and popularity of sports for individuals with disabilities, there remains a notable lack of published research focused on understanding injury patterns and risk factors among elite disabled athletes (Sobko & Sterin, 2024).

There are six classification groups in Para badminton which are as follows:

1. **Wheelchair WH 1:** Players with limitations in lower limb and trunk function, competing in a wheelchair.

2. **Wheelchair WH 2:** Players with limitations in one or both lower limbs and minimal or no trunk restriction, also competing in a wheelchair.

3. **Standing Lower SL 3:** Players with standing impairment, exhibiting impaired function in one or both lower limbs and poor walking balance.

4. **Standing Lower SL 4:** Players with standing impairment, albeit less severe compared to SL 3, with possible impairment in one or both lower limbs and minimal walking balance impairment.

5. **Standing Upper SU 5:** Players with upper limb impairment, affecting either the playing or non-playing hand.

6. **Short Stature SH 6:** Players with genetically determined short stature, characterized by normal limb function but limited reach.

These classifications play a crucial role in maintaining fair competition by categorizing athletes based on comparable physical abilities. This system enables individuals with diverse types and degrees of impairment to compete under equitable conditions, thereby upholding the integrity of competitive sports.

Understanding the epidemiology of injuries is vital to provide better planning and athlete health care and further the development of measures to prevent injuries and illness (Goh et al., 2013). It is noteworthy that a significant number of elite Para badminton players originate from India. However, to date, there has been no comprehensive study examining the epidemiological nature of Para badminton-related injuries globally. This study aimed to investigate the incidence and distribution of injury pattern in Para badminton players

on the basis of gender, various categories of Para badminton athletes and combined wheelchair and non-wheelchair classes who participated in Khelo India Paragames 2025.

Methodology

Participants. A total of 144 players (96 men and 48 women) participated in the national tournament. Since, all elite players with good world-rankings participated during the tournament, hence, it was assumed that all the players were injury-free and have recovered if any injury occurred to them. Thus, all the players having any musculoskeletal symptoms participating during the tournament were included in our study.

Measurement of variables. Musculoskeletal injuries were defined as any musculoskeletal symptoms that occurred during the tournament for which the player had to report at the medical help desk. Data on the athlete's identity, demographic characteristics (category and sex) and musculoskeletal injuries (anatomical location) were extracted from the records of the medical help-desk. We also obtained data on the number of matches and their duration for each specific playing category.

Calculation of Injury Incidence Rate, incidence rate ratio and analysis of injury pattern distribution was done on the basis of gender, various categories of Para badminton athletes and combined wheelchair and non-wheelchair athletes.

Procedure. A prospective epidemiological study was conducted that used the records from the medical help-desk established at the Para badminton venue in Khelo India Paragames 2025 for three consecutive days. The records were maintained by the sports physician and physiotherapists for each of the participating Para badminton athlete during the whole tournament.

Analysis. IIR (Injury Incidence Rate) was measured as 1000 AE (Athlete Exposure), with 1 AE defined as participation in 1 sports session by 1 player. The incidence rate ratio and injury incidence rate per 1000 athlete-hours of exposure in our study is calculated as follows:

Injury Incidence Rate = (Number of Injuries / Total Athlete Exposure Hours) × 1000

Incidence Rate Ratio = Injury Incidence in class 1 / Injury Incidence in class 2

Where: **Athlete Exposure Hours =** (Total Duration in minutes ÷ 60) × Total Players

Chi-square tests were conducted to compare injury pattern distribution on the basis of gender, various categories of Para badminton athletes and combined wheelchair and non-wheelchair classes. The incidence rate ratio was calculated, with 95% confidence interval (CI) using Poisson distribution. Significant differences in values between groups (gender, various categories of Para badminton athletes and combined wheelchair and non-wheelchair classes) for incidence rate ratio were assumed if the 95% CI did not overlap. For statistical analysis, differences were considered significant at $p < 0.05$. All statistical analysis was conducted using SPSS v. 26.0.

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RESULTS

Injury Incidence: (Table 1)

On the basis of gender

Based on the injury data analysis, this study examined injury patterns across 144 total athletes during the national tournament. The research tracked injuries across 125 total matches, with men's competition involving 86 matches lasting 2,421 minutes and women's competition comprising 39 matches over 873 minutes. The injury incidence analysis reveals significant disparities between genders and player categories in Para badminton during the tournament. Men recorded 31 total injuries across 3,873.6 athlete-hours of exposure, while women sustained 19 injuries during 698.4 athlete-hours. Women athletes demonstrate a substantially higher injury rate, with 27.20 injuries per 1000 athlete-hours compared to men's 8.00 injuries per 1000 athlete-hours. This nearly threefold difference persists despite men having more total injuries, which can be attributed to their significantly longer exposure time.

The overall injury incidence in men was found to be 0.32, whereas, in women it was 0.39. The incidence rate ratio on the basis of gender was 3.40 (95% CI: 1.93 – 5.98). Highly significant difference was found in incidence rate ratio on the basis of gender ($p < 0.001$) (Chi squared test).

On the basis of various categories in Para badminton athletes: (Fig. 1)

Based on the Para badminton injury analysis across six classification categories, the study reveals significant variations in injury incidence rates that don't always align with expected patterns based on disability severity. The SH6 classification demonstrated the highest injury risk, recording 9 injuries over 161.5 athlete-hours, resulting in an incidence rate of 55.72 injuries per 1000 athlete-hours, categorized as "Very High" risk. Similarly concerning was the SL4 classification, which showed 50.14 injuries per 1000 athlete-hours from 9 incidents across 179.5 exposure hours, also classified as "Very High" risk. The middle-tier risk categories included WH2 at 37.05 injuries per 1000 hours and SU5 at 35.64 per 1000 hours, both categorized as "High" risk. The moderate risk classifications were SL3 at 32.29 per 1000 hours and WH1 showing the lowest rate at 25.69 per 1000 hours.

Several unexpected findings emerged from this analysis. Most notably, the SH6 category exhibited the highest injury rate despite having minimal anatomical limitations compared to other classifications. Additionally, SL4 athletes showed higher injury rates than SL3 athletes, which contradicts expectations since SL4 represents a less severe classification level.

The injury risk on the basis of various categories of Para badminton athletes was reported to be 1.35 at 5 degrees of freedom. Non-statistically significant differences in injury risk were observed based on various categories of Para badminton athletes (p = 0.93) (Chi squared test).

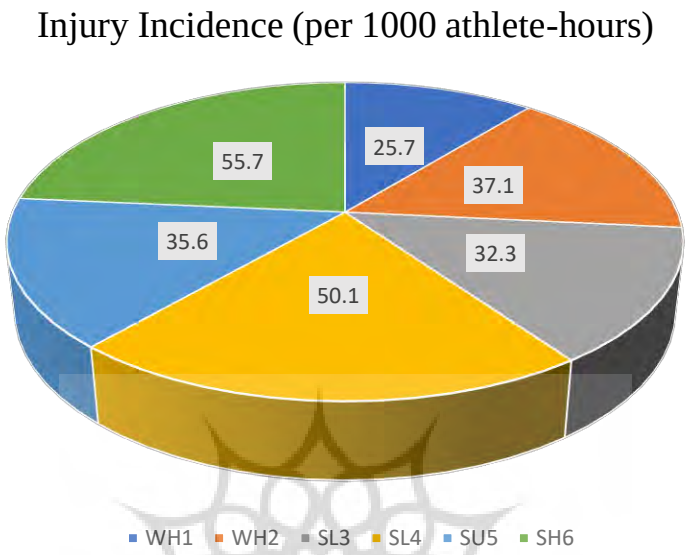

Fig. 1: Injury Incidence (per 1000 athlete-hours) in various categories of Para badminton athletes.

On the basis of combined wheelchair and non-wheelchair classes

The data also highlighted differences between wheelchair and non-wheelchair player categories. Wheelchair players (WH1 and WH2 classifications) experienced 15 injuries across 952.8 athlete-hours, resulting in an injury incidence rate of 15.74 per 1,000 athlete-hours. Non-wheelchair players (SL3, SL4, SU5, and SH6 classifications) recorded 35 injuries over 3,364.8 athlete-hours, with an injury incidence rate of 10.4 per 1,000 athlete-hours. This indicates wheelchair players face approximately 1.5 times higher injury risk during competition.

The overall injury incidence in wheelchair athletes was found to be 0.31, whereas, in non-wheelchair athletes it was 0.36. The incidence rate ratio on the basis of combined wheelchair and non-wheelchair athletes was reported to be 1.51. Non-statistically significant differences in incidence rate ratio were observed based on combined wheelchair and non-wheelchair classes (p = 0.179) (Chi squared test).

Table 1: Injury distribution in relation to matches and their duration.

Class	Total players	Matches	Duration (mins)	Injury
MEN				
WH1	16	15	426	4
WH2	16	15	454	6
SL3	16	14	455	3
SL4	16	14	343	7
SU5	16	14	460	5
SH6	16	14	283	6
WOMEN				
WH1	8	7	158	2
WH2	8	7	153	3
SL3	8	5	164	5
SL4	8	6	106	2
SU5	8	7	171	4
SH6	8	7	121	3
Total	144	125	3294	50

Distribution of Anatomical Region

On the basis of gender: (Fig.2), (Table 2)

Anatomical injury patterns varied distinctly between groups. Male athletes predominantly suffered upper extremity injuries, with 42% of their injuries occurring in the hands, elbows, and shoulders. Female athletes showed more diverse injury patterns, with ankle injuries representing their most common concern. The value of Chi-square test of independence at 6 degrees of freedom was reported to be 3.69. Non-statistically significant differences in injury distribution pattern were observed based on gender ($p = 0.72$).

Table 2: Anatomical Distribution of Injuries on the basis of gender in Para badminton athletes.

Location	MEN	WOMEN
Hand (%)	6.45	10.53
Elbow (%)	22.58	15.79
Shoulder (%)	12.9	15.79
Back (%)	22.58	10.53
Hip (%)	6.45	5.26
Knee (%)	19.35	15.79
Ankle (%)	9.68	26.31

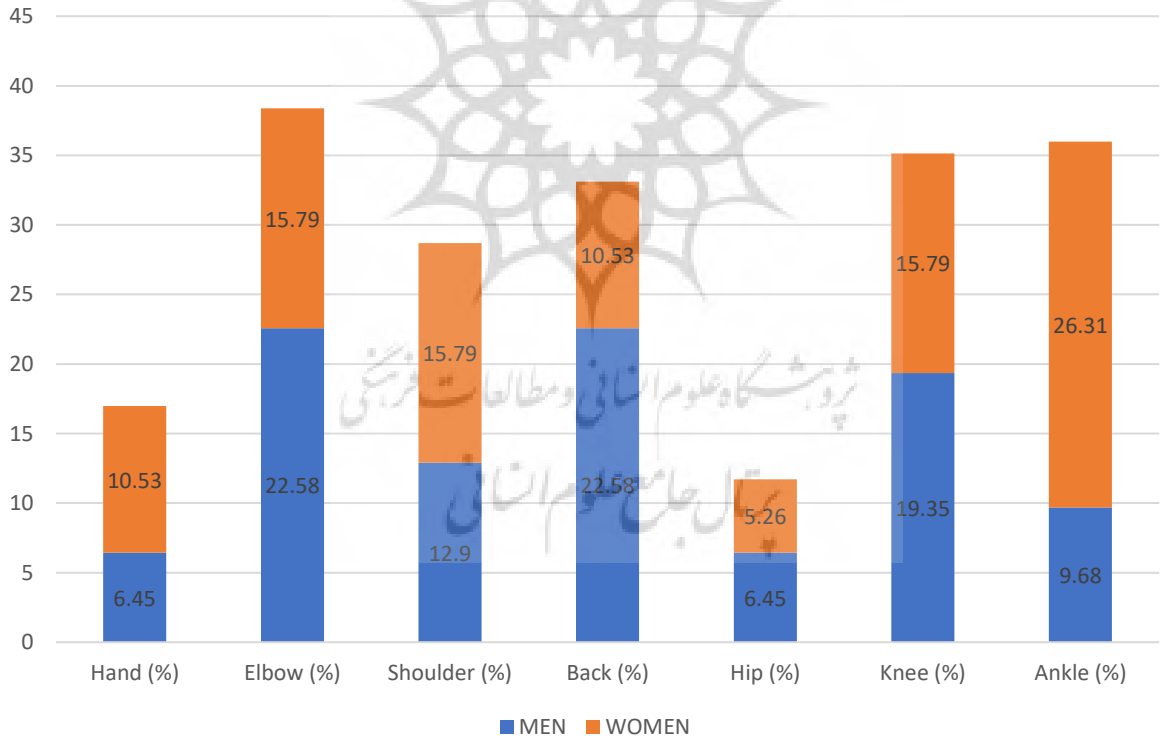

Fig. 2: Anatomical Distribution of Injuries (in percentage) on the basis of gender.

On the basis of various categories of Para badminton athletes: (Fig. 3), (Table 3)

Based on the Para badminton injury analysis examining anatomical injury rates across classification categories with equal participant distribution, the study reveals significant variations in injury patterns among the 144 total players (24 players per classification). The injury rate analysis shows that WH1 athletes had the lowest injury rate at 25%. In contrast, four classifications - WH2, SL4, SU5, and SH6 - all demonstrated identical injury rates of 37.5%, each recording 9 injuries among their respective 24 players. The SL3 classification fell between these groups with a 33.3% injury rate. WH1 players demonstrated a greater focus on upper body injuries, likely reflecting the increased upper limb demands placed on athletes with limited trunk function. The value of Chi-square test of independence was reported to be 39.57. Non-statistically significant differences in injury distribution pattern at the 0.05 level were observed based on various categories of Para badminton athletes ($p = 0.113$).

Table 3: Anatomical Distribution of Injuries on the basis of various categories in Para badminton athletes.

Location	WH1	WH2	SL3	SL4	SU5	SH6
Hand (%)	16.67	11.11	-	22.22	-	-
Elbow (%)	50	33.33	-	-	33.33	11.11
Shoulder (%)	16.67	22.22	12.5	-	22.22	11.11
Back (%)	16.67	22.22	-	33.33	-	33.33
Hip (%)	-	-	12.5	-	22.22	-
Knee (%)	-	11.11	37.5	33.33	-	22.22
Ankle (%)	-	-	37.5	11.11	22.22	22.22

On the basis of combined wheelchair and non-wheelchair classes: (Fig.4), (Table 4)

Among wheelchair players, there was a strong upper extremity dominance with 74% of injuries affecting the hand, elbow, and shoulder regions, with elbow injuries being most frequent due to repetitive overhead motions and wheelchair propulsion demands. Non-wheelchair players demonstrated a more varied injury distribution with higher prevalence of lower extremity injuries, particularly affecting the ankle and knee regions. The value of Chi-square test of independence at 6 degrees of freedom resulted to be 11.89. Non-statistically significant differences in injury distribution pattern at the 0.05 threshold were observed based on combined wheelchair and non-wheelchair classes ($p = 0.064$).

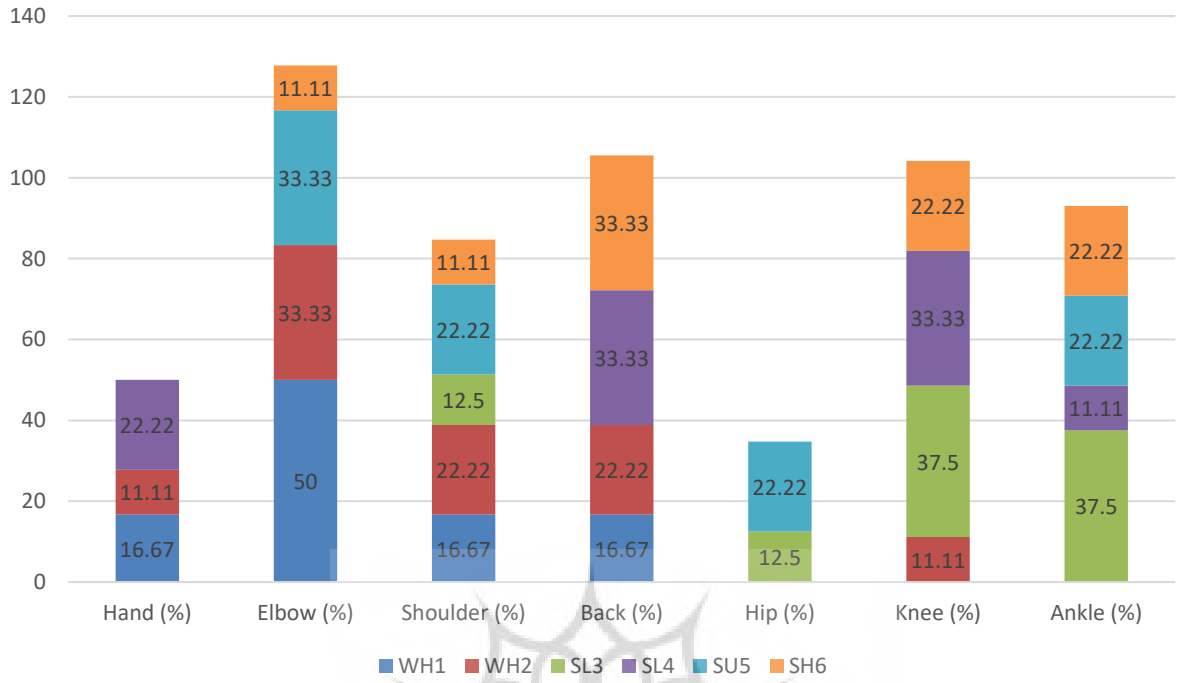

Fig. 3: Anatomical Distribution of Injuries (in percentage) on the basis of various categories in Para badminton athletes.

Table 4: Anatomical Distribution of Injuries on the basis of combined wheelchair and non-wheelchair categories in Para badminton athletes.

Location	Wheelchair	Non-Wheelchair
Hand (%)	13.33	5.71
Elbow (%)	40	11.43
Shoulder (%)	20	11.43
Back (%)	20	17.14
Hip (%)	-	8.57
Knee (%)	6.67	22.86
Ankle (%)	-	22.86

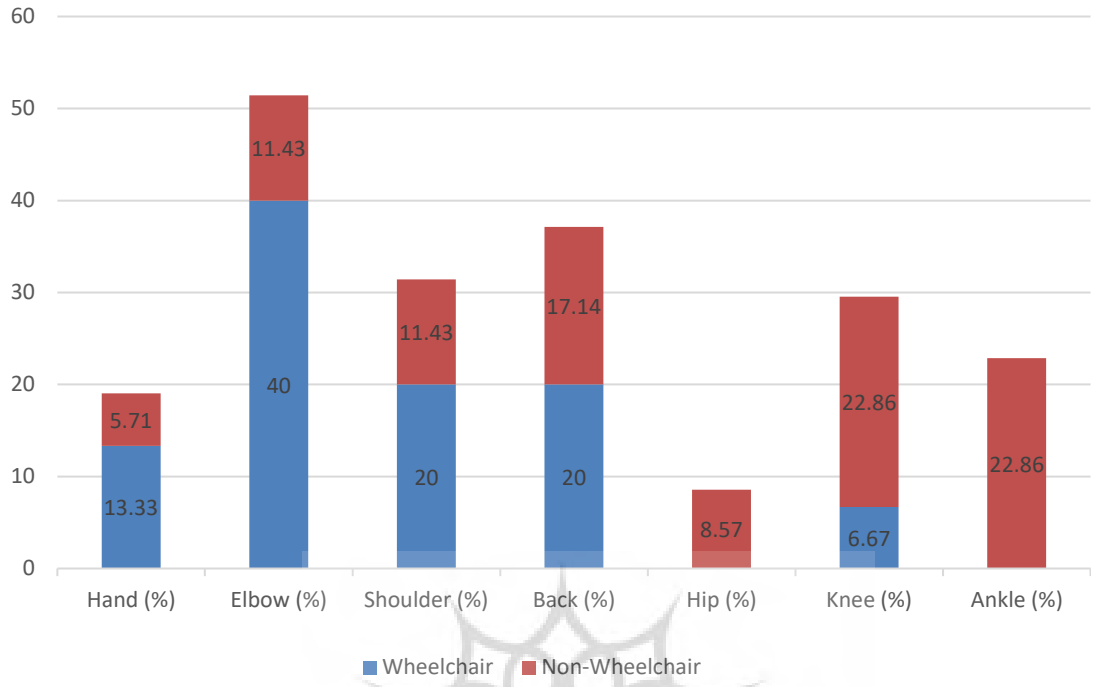

Fig. 4: Anatomical Distribution of Injuries (in percentage) on the basis of combined wheelchair and non-wheelchair categories in Para badminton athletes.

DISCUSSION

Para badminton is a sport that places significant biomechanical demands on its participants (Janiaczyk, 2015). As a non-contact sport, it demands jumps, lunges, and quick directional changes, along with rapid arm movements from various postural positions (Guermont et al., 2021), (Kaldau et al., 2021). The results from the Khelo India Para Games injury study show moderate-to-high injury incidence rates, substantial sex differences, and unexpected patterns by classification.

Para badminton, as compared to badminton, requires rapid positional adjustments and dynamic movements, including lunges, jumps, twists, and swings (Kang & Ramalingam, 2018), (Saragaglia et al., 2023). The substantially higher injury rates in Para badminton emphasize the need for specialized injury prevention programs tailored to the unique demands of adaptive sport (Shariff et al., 2009), (Mohd Jamali et al., 2022).

Incidence Proportion of Injuries: The most pronounced finding is the difference in injury incidence between male and female athletes. Despite men sustaining more total injuries, women experienced a significantly higher injury rate per 1000 athlete-hours—over threefold compared to men (27.2 vs 8.00). This suggests intrinsic vulnerability in female athletes, possibly due to differences in biomechanics, training exposure, physiological factors, or levels of support.

Conversely, in a prospective epidemiological study related to badminton (Hoy et al., 1994), men comprised 58% of injuries with a mean age of 31 years, compared to women at 42% with a mean age of 25 years. No statistically significant difference was found between male and female injury patterns in Kaldau et al.

(Kaldau et al., 2021). Compared to an article comprising of Japanese national tournament-level badminton players from junior high school to university (Miyake et al., 2016), Para badminton rates (8.00-27.20 per 1000 hours) are 3-10 times higher than elite youth rates (0.9-5.1), representing one of the largest injury rate disparities documented between badminton populations. Similar observations of injury rates were reported in Pardiwala et al. (Pardiwala et al., 2020). Para badminton athletes demonstrate substantially higher injury rates, with female Para badminton players showing rates more than 17 times higher than elementary school players in Zhou et al. (Zhou et al., 2023). This dramatic difference likely reflects several factors: higher competitive intensity, different playing demands, and the unique physical challenges faced by athletes with disabilities.

Wheelchair athletes presented roughly 1.5 times higher injury risk than non-wheelchair athletes (15.74 vs 10.40 injuries per 1000 athlete-hours), although differences were non-significant statistically. These observations necessitate the implementation of distinct injury prevention strategies that are specifically tailored to an individual's mobility status. For wheelchair athletes, this includes the strengthening of upper limbs and the design of ergonomic wheelchairs. Conversely, for non-wheelchair athletes, it involves targeted proprioceptive or neuromuscular training.

Reported injury rates for Para badminton ranged from 8 to 55.72 injuries per 1000 athlete-hours. Systematic reviews across para sports (Luijten et al., 2024) show substantial variability, typical rates for elite-level para sports clustering between 10 and 50 per 1000 athlete-days depending on sport type and athlete impairment. Wheelchair sports, such as wheelchair basketball (Weith et al., 2023), commonly demonstrate rates from 12 to 69 per 1000 athlete-hours; similar patterns are seen with higher injury susceptibility in athletes with greater movement demands or impairment-related compensations. Rates between 20.9–91 per 1000 athlete-hours were observed in a study based on Winter Paralympic Games (Wu et al., 2022) and bone stress injury rates varying between 11–14 per 1000 athlete-days were observed in a study based on NCAA athletes (Bratsman et al., 2021).

Unexpectedly, the SH6 classification had the highest injury rate, challenging assumptions that severity of impairment always corresponds to increased risk. This echo other studies showing that injury risks may be high both in athletes with minimal anatomical restrictions (due to sport-specific strain) and in athletes with major impairments (due to compensation and adaptive demands).

Anatomical Distribution of Injuries: The repetitive nature of these maneuvers imposes significant stress on both the upper and lower extremities, consequently elevating the risk of both acute and chronic injuries of varying severity (Rangasamy et al., 2022).

In our study, 42% upper extremity injuries (hands, elbows, shoulders) were reported in men, while, in women, more diverse patterns with ankle injuries were most common. Upper extremity involvement was common especially in wheelchair players (74%).

Furthermore, Kroner et al. (Kaldau et al., 2021), reported 82.9% lower extremity injuries and 11.1% upper extremity injuries across all players. In a review based on badminton injuries in elite players (Pardiwala et al., 2020), lower extremity injuries (58-92.3%) were dominated. In an interview-based descriptive study on Indonesian recreational badminton players (Karyono et al., 2022), 74% lower extremity injuries were reported.

Complete reversal was observed on the basis of anatomical distribution of injuries.
Upper extremity injuries dominated wheelchair athlete reports and male athletes, whereas lower limb injuries (especially ankle and knee) were more common in non-wheelchair classes and female athletes—patterns supported by research in para basketball (Weith et al., 2023), track and bone stress injuries in NCAA athletes (Bratsman et al., 2021).

LIMITATIONS

The limited sample size employed in our study presents considerable constraints on the generalizability of our findings, thereby limiting our capacity to extend these results to broader populations or varied contexts. Furthermore, the lack of a comprehensive clinical assessment raises significant concerns about the accuracy and reliability of the health data collected during this study. This issue may ultimately affect the robustness and validity of the conclusions derived from this research. Therefore, it is essential that future research endeavours prioritize larger sample sizes to enhance statistical power and provide a more reliable foundation for interpretation.

The data were collected over just three consecutive days during a single tournament, which limits the ability to capture injuries that may develop over longer periods of training, competition, or recovery. The study exclusively involved elite athletes presumed to be injury-free at the outset, which may inadvertently exclude individuals with pre-existing injuries or chronic conditions who could be at an elevated risk. Consequently, this selection criterion may introduce a "healthy participant" bias that influences the observed injury rates.

Musculoskeletal injuries were defined as symptoms requiring medical help desk attention, which may miss less severe injuries, underreported symptoms, or cases managed independently by athletes. The design of the study lacks provisions for monitoring long-term injury outcomes, recurrence, or rehabilitation processes. These elements are crucial for the comprehensive assessment and management of Para athlete health.

CONCLUSION

Maintaining objectivity and consistency while accounting for the diverse range of disabilities and their impact on performance in Para badminton players is a formidable task. Given the limited sample size and focus on a single national event, broader multi-centric studies are necessary to generalize findings and guide best practices.
The implementation of enhanced surveillance, advancements in biomechanical research, and the fortification of support systems—encompassing physiotherapy and coaching resources—are imperative for minimizing the risk of injury and optimizing the health of athletes. Such insights are fundamental not only for Para badminton but also for the wider field of disability sports medicine, policy-making, and the development of inclusive sport environments. It is imperative that future research undertakes a thorough examination of the optimal training volume necessary to prevent pain and injuries among Para sports

athletes. Enhancing warm-up protocols to ensure effective muscle activation, alongside strategies to avoid overtraining, could significantly contribute to reducing the incidence of injuries.

Acknowledgements: None
Funding: None
Conflict of Interest: None
Author Contributions: NS and PS wrote and reviewed the manuscript. NS designed the tables and figures too.

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